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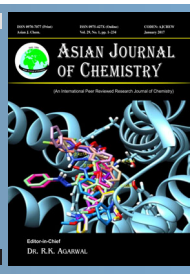

Physico-Chemical, Nutritional, Functional, Textural and Morphological Characterization of Sand Pear Fruit (*Pyrus pyrifolia* L.) from Northern Region of India

POONAM BANIWAL* and BAHADUR SINGH HATHAN

Department of Food Engineering and Technology, Sant Longowal Institute of Engineering & Technology, Sangrur-148 106, India

*Corresponding author: Fax: +91 1672 280057; E-mail: pbaniwal@gmail.com

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The present study was aimed to study the proximate, physico-chemical properties and nutritional components including total sugar, reducing sugar, ascorbic acid and minerals of sand pear cultivated in North India. The following physical properties *i.e.* weight, polar length, equatorial length and colour of the sand pear were also studied. Furthermore the pear cultivar was characterized for functional properties with respect to total phenolic contents analysis and total dietary fiber analysis. The results indicated that the fruit is a good alimentary source of sugars, minerals, ascorbic acid and polyphenols. The edible part of the fruit has a high level of total dietary fiber content. Additionally, textural properties in terms of hardness and morphological properties (scanning electron microscopy) of the fruit were also studied. The overall results indicate that sand pear could be best for utilization or favourable practicing owing to excellent product quality and high concentrations of nutritional and functional compounds.

Keywords: Sand pear, Physico-chemical, Nutritional, Total dietary fiber, Hardness, Morphology.

INTRODUCTION

Fruits are the important sources of essential dietary nutrients and regarded as good foods. They are the major sources of nutrients such as vitamins, carbohydrate, minerals in particular vitamin C, folic acid and dietary fiber. Foods of plant origin have the ability of contributing considerable quantities of nutrients, including protein which is needed by both adults and children if processed and blended properly [1]. Pear is a fruit native to temperate zones and grown under subtropical conditions [2]. The sand pear or oriental pear (*Pyrus pyrifolia* L.) is cultivated in India in the semi temperate regions of the following states *i.e.* Punjab, Haryana, Uttar Pradesh, some part of Nilgris and North east region. The fruit bears hard texture, due to this it is also known as "Pathernakh". As the fruit is seasonal in nature, therefore it is typically consumed as fresh. It is popular among consumers because of its sweetness, fragrance, specific aroma and crispness. Because of the few stone cells, it possesses the great eating quality. The flavour of the pear is analogous with its content of sugar. Fully mature pear fruits are directly consumed as a source of monosaccharide and minerals [3]. For its antitussive, anti-inflammatory and diuretic activities, pear has also been utilized as a herbal medicine for many years [4].

Apart from their abundance in macronutrients, they also are endowed with other nutritional components such as vitamins, minerals and antioxidants as well as bioactive elements *i.e.* plant sterols and carotenoids that are the important sources of health beneficial compounds [5-7]. The analyses of these nutritional components of pear have been recently focused by the researchers [8]. Total sugars, soluble solid content and titratable acidity are the certain chemicals which have been significant parameters as they have the great influence on the organoleptic properties of the fruit [9]. Besides the above chemical and nutritional properties, various phenolic compounds are also identified as the primary active compounds in pears [10,11]. These compounds have a beneficial antioxidant property which help in preventing the low density lipoprotein (LDL) oxidation and decreases the incidence of coronary diseases. Among the several classes of plant phenolics component, four components have been reported in pear fruits *i.e.* phenolic acids, flavonols, flavon-3-ols and anthocynin [12]. Pears are sodium-free, fat-free and cholesterol-free where as rich in potassium, all these play important role in cardiovascular disease prevention [13]. Pear fruit holds a high percentage of water as their fresh weight and thus exhibits comparably high metabolic activity with other plant derived foods such as seeds and this activity continues after harvesting which makes the fruit highly perishable. It exhibits a short shelf life at refrigerated temperatures. Also during storage there is a development of brown to dark-brown areas in the core without any indication of internal browning of the fruit and therefore, unexpected

economic losses may occur. On review of the various literatures as well as statistics obtained from the FAO [14]; there is stagnated or meager rise in the pear production over the period has been observed (Fig. 1). The possible reason may be that there are only few products of the sand pear and thus not gain much attention towards its production. Considering this aspect, in our earlier research, a product from sand pear *viz*. RTE instant sand pear candy [15] was prepared which may bring a new industrial revolution in the production/products in the due course of time. In the same line of thinking, the focus of this research is to analyze the physico-chemical, functional and nutritional properties of the sand pear (*Pyrus pyrifolia* L.), so that it give a good platform for the further research to produce or to think of other new products and convenient processing characteristics of the sand pear fruit.

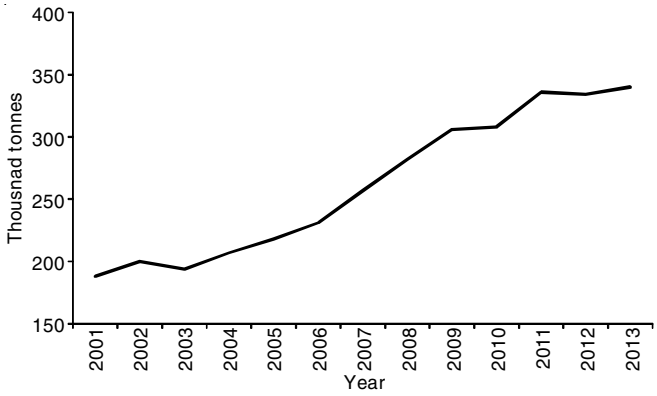

Fig. 1. Pear production in India during 2001 to 2013

EXPERIMENTAL

Pear cultivar from *Pyrus pyrifolia* L. *i.e*. sand pear was sampled and used in the study. Fresh sand pear fruits were procured from the local market of Sangrur, Punjab, India. The samples selected were of uniform size, maturity and free from defects. The graded whole pear fruits were washed thoroughly under running tap water.

Physico-chemical analysis: Weight, polar and equatorial length, pH and titratable acidity were analyzed using the fresh sand pears. The fresh weight was measured from 10 randomly chosen sand pear fruits by weighing using an analytical balance. Polar and equatorial length of fresh sand pear fruit was measured by using a vernier caliper. Total soluble solids were determined using a fruit juice with a hand refractometer (Erma, Japan). The pH was measured with the help of pH meter (Microsil, India). The titratable acidity was determined by using the NaOH titration method [16].

Proximate composition analysis: Moisture content was determined by hot air oven method [17]. Crude fiber, protein, fat and ash contents were measured by using the standard methods [18].

Nutritional composition analysis: Reducing sugars, ascorbic acid and minerals were analyzed using the fresh sand pear fruits. The sand pear fruits with same uniformity and having no defects were selected for the experiments. Each fruit was washed peeled and cut into thin slices and grinded with homogenizer for the preparation of the sand pear fruit juice.

Reducing sugar and Total sugars: Fehling's solution method [19] was used to determine the reducing sugars and total sugars.

Ascorbic acid: Ascorbic acid content of the sand pear fruit was determined by the titrimetric method [20].

Mineral content analysis: Mineral content analysis was determined by using AOAC method [17]. 1 g sample was weighed and dispersed in a 150 mL conical flask and 25-30 mL diacid mixture (HNO_3:$HClO_4$) in ratio 5:1 was added in flask and kept overnight. The contents were digested by heating until clear white precipitates settled down at bottom of flask. The crystals left were dissolved by adding double distilled water. The contents were filtered through filter paper (Whatmann No. 42). The filtrate was made to 50 mL volume by using double distilled water and used for the determination of trace minerals using atomic absorption spectrophotometer [21].

Total dietary fiber: The total dietary fiber content was determined by an enzymatic method of AOAC [18].

Total phenolic content: Gallic acid (10 mg) for the preparation of standard solution was accurately weighed into a volumetric flask of 10 mL. Dissolved it in 10 mL methanol and the solution was made up to 10 mL with the same solvent (1 mg/mL). The amount of total phenolics in extracts was determined with the Folin-Ciocalteu reagent. Gallic acid was used as a standard and the total phenolics were expressed as mg/100 g gallic acid equivalents (GAE). 1 mL of standard solution of concentration 0.01, 0.02, 0.03, 0.04 and 0.05 mg/mL of gallic acid were prepared in methanol. Concentration of 0.1 and 1 mg/mL of plant extract were also prepared in methanol and 0.5 mL of each sample were introduced into test tubes and mixed with 2.5mL of a 10 fold dilute Folin-Ciocalteu reagent and 2 mL of 7.5 % sodium carbonate. The tubes were covered with parafilm and allowed to stand for 30 min at room temperature before and the absorbance was at read at 760 nm spectrometrically. Double distilled water was used as the blank [22,23].

Textural profile analysis: Texture measurement of fresh fruit was performed using a universal test machine (TA.XT.2I, Stable Micro Systems Ltd, Godalming, UK) with a 30 N load cell and an aluminum cylindrical probe of 50 mm diameter at room temperature of 25 °C. The program was set to measure force in compression mode, considering a 60 % relative deformation. The test parameters were 1.00 mm/s of pre-test and post-speed, 0.5 mm/s of test speed and 10 g of trigger force. Hardness was measured as peak maximum force. All of the measurements were replicated thrice and the mean values were reported.

Morphological characterization: Morphological characterization was done by scanning electron microscopy (SEM). The samples used were cut from the fleshy tissue of fresh sand pear and fixed in glutaraldehyde and dehydrated in a graded ethanol series (20-100 %). Samples were then mounted on different aluminium stubs using double-sided conductive tapes and then coated with gold under vacuum. The coated samples were scanned under different magnification to get a clear micrograph using scanning electron micrograph (JEOL, JSM-6510LV, Tokyo, Japan).

Water activity: Water activity meter (Hygrolab, Cole Parmer) was used to measure the water activity. The sample was cut into tiny pieces and placed in a sample cup and another

water activity measurement was made immediately to restrict moisture transfer from the air to the samples.

Colour analysis: The colour of the sand pear fruit was determined by using handheld chroma meter (CR-400, Konica Miolta, U.K.). The tristimulus values of L* a* b* were recorded from the colorimeter. L* represents lightness, a* represents redness and b* represents the yellowness.

Statistical analysis: For statistical analysis Excel (Microsoft corp., USA) was used. All the determinations were carried out at least by triplicate and expressed as means ± SD.

RESULTS AND DISCUSSION

Physico-chemical analysis: Sand pear fruits analyzed were round in shape and also have an apple like shape. The weight, polar and equatorial length is given in Table-1. The total soluble solids (TSS) of the fruits is widely used during the processing of fruits to determine the concentration of sugar in the products. Total soluble solids observed for the sand pear fruit was 13.2 ± 0.05 °Bx which is slightly less than the other pear species *i.e. Pyrus communis* and greater that *Pyrus bretscheideri* and *Pyrus ussuriensis* [4]. The flavour of the sand pear fruit is a mixture of juicy, sweetness and astringency and it also possesses a unique aroma. The pH of the sand pear observed was acidic *i.e.* 3.9 ± 0.15. This value is similar to the pH value of the apple juice from Red Delicious, Kala Kulu and Golden Delicious prepared after peeling [24].

TABLE-1
PHYSICO-CHEMICAL ANALYSIS OF SAND PEAR FRUIT

Weight of fruit[a] (g)	303.8 ± 8.84
Polar length[a] (cm)	6.56 ± 0.28
Equatorial length[a] (cm)	5.80 ± 0.18
TSS[b] (°Brix)	13.2 ± 0.05
pH[b]	3.8 ± 0.15
Titratable acidity[b] (per cent of malic acid)	0.10 ± 0.01

[a]The values are the mean ± SD of atleast 10 measurements.
[b]The values are the mean ± SD of atleast 5 measurements.

The titratable acidity is the parameter to measure the amount of organic acids present in the fruit. The major acid of the sand pear is malic acid [25]. The titratable acidity of sand pear slices was found to be 0.10 ± 0.01 (% of malic acid) which is slightly lower than the other pear varieties [4].

Proximate composition analysis: The results to pertain proximate composition of sand pear *i.e. Pyrus pyrifolia* L. have been reported in Table-2. Moisture content of the sand pear represented the single largest content among the proximate composition. It was evident that, after the moisture content crude fiber was in the second biggest proximate composition in the sand pear tissues, followed by ash. Fiber helps in maintaining human health by reducing the cholesterol level in the body. Furthermore, it also decreases the risk of various cancers and helps in boosting general health [26]. The protein content of sand pear fruit was found lower as corresponding data for several pear fruits reported by various researchers. Also, the fat content of sand pear was found relatively low as compared to the other pear fruits. However it is significant that low levels of fats are common in fruit pulp and would not have a great nutritional importance [27]. The total carbohydrates content reported in sand pear was 1.71 ± 0.63 %. Carbohydrates in the feed are desirable because it is needed for growth and strong health and its deficiency causes the depletion of body tissues [28].

TABLE-2
PROXIMATE COMPOSITION ANALYSIS OF THE SAND PEAR FRUIT

Proximate composition (g/100 g)	
Moisture	88.23 ± 0.63
Crude fiber	7.32 ± 0.28
Crude ash	1.86 ± 0.03
Crude protein	0.61 ± 0.04
Crude fat	0.24 ± 0.04
Total carbohydrate	1.79 ± 0.63

All experiments were carried out in triplicate.

Nutritional composition analysis

Total sugars and reducing sugars: The sweetness of the fruit is contributed by its sugar content *i.e.* sucrose, fructose, glucose and sorbitol in its flesh [29]. In this study total sugar and reducing sugar content estimated was 5.45 ± 0.06 % and 3.27 ± 0.06 % [4,30] also observed the almost similar values of total sugars of different pear varieties. The sugar analysis of the fruit is the significant factor of chemical composition tables. It provides important information regarding the sweetness characteristics of the fruit.

Ascorbic acid: Ascorbic acid is important for growth and repair of tissues in all parts of the body. It helps the body in making collagen which is an important protein used for making skin, cartilage, tendons, ligaments and blood vessels. But it cannot be synthesize in humans, rendering its ingestion from exogenous supplement or diet necessary [31]. In sand pear, the ascorbic acid content reported was 4.1 ± 0.30 mg/100 g, this level turns out to be higher or almost similar than that found in most common fruits such as green grapes and red plum *i.e.* 2 mg/100 g and 5 mg/100 g respectively and vegetables such as onion, spinach, green cabbage [32].

Mineral analysis: Mineral analysis of sand pear is listed in Table-3. According to the results reported the sand pear is rich in potassium contents followed by phosphorous, calcium and magnesium. Their presence in the diet is desirable to ensure proper mineral nutrition in humans. Pears are sodium free and fat free. From nutritional point view, sand pear may be considered as a good source of minerals, especially potassium because a significant amount of dietary potassium is recommended for primary prevention of hypertension or acute or chronic renal failure [33].

TABLE-3
NUTRITIONAL COMPOSITION AND MINERAL ANALYSIS OF THE SAND PEAR FRUIT

Nutritional compositional analysis	
Reducing sugar (%)	3.27 ± 0.06
Total sugar (%)	5.45 ± 0.06
Ascorbic acid (mg/100 g)	4.1 ± 0.30
Minerals analysis (mg/100 g)	
K	104.04 ± 1.12
Ca	16.59 ± 0.31
Mg	12.73 ± 0.41
P	18.20 ± 0.22

All experiments were carried out in triplicate.

Total dietary fiber: Dietary fiber plays a vital role in preventing the risks of many disorders like constipation, cardiovascular diseases, diabetes and obesity [34]. The total dietary fiber of sand pear reported was higher as compared to the other fruits such as apple, jackfruit, ziziphus, fig and custard apple *i.e.* 3.2, 3.5, 3.8, 5.0 and 5.5 %, respectively [35]. Due to this high content of total dietary fiber in the sand pear can be seen as the potential food additive in other foods. The major part of dietary fiber in fruits and vegetables is comprised of polysaccharides which are beneficial to healthy human volunteers, because the consumption of fiber lowers plasma cholesterol level [36].

Textural analysis: Texture is a quality characteristic used in the fresh and processed food industry to assess the product acceptability and quality. Hardness (firmness) being one of the most important parameters of fruit and vegetables among the texture characteristics is often used to ascertain the freshness of food [37]. The fresh sand pear had the hardness value of 1.61 ± 0.04 kgf.

Morphological characterization (SEM): Scanning electron microscopy is a technique that gives the information regarding the external morphology (*i.e.* texture), crystalline structure and may also upgrade the interpretation of the changes in quality factor, mainly the changes in the texture of food [38]. The primary aim of this work is to evaluate the microstructure of the fresh sand pear slices. Figs. 2 and 3 show the micrograph of the fresh sand pear fruit. In the micrograph it is clearly seen that fresh sand pear has a well-organized structure which consists of cells and intercellular spaces. Various processes such as osmotic dehydration, drying *etc.* affects the microstructure of fruits and vegetables. Baniwal and Hathan [15] reported the shrinkage of cells, folding of cell walls and plasmolysis while preparing the sand pear candy. Also the microstructural analysis of the fruits and vegetables helps in understanding the different mechanisms occurs during the different reaction and processes like drying and dehydration. The numbers of pores and pore sizes can also influence the food texture. Pores having smaller size and smaller number deceases the hardness of the fruit sample.

Colour analysis: Colour is an important characteristic of quality of food which is initially judged at purchasing the food by a consumer. The colour of various fruits and vegetables either raw or processed is dependent on many factors. That is why the colour parameters of sand pear slices were measured. The values of of lightness (L*), redness (a*) and yellowness (b*) of the fresh sand pear reported were 40.22 ± 1.21, 2.23 ± 0.17 and 9.74 ± 1.40, respectively.

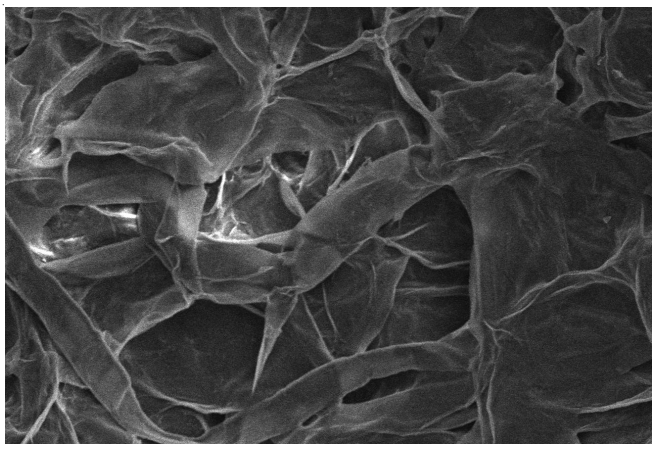

Fig. 2. Scanning electron micrograph of fresh sand pear at 50 µm

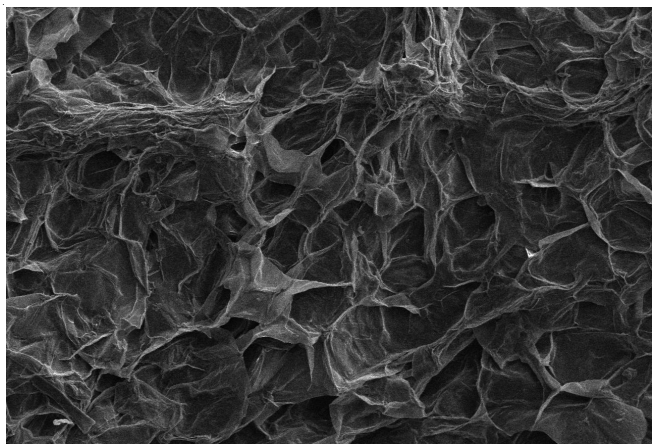

Fig. 3. Scanning electron micrograph of fresh sand pear at 100 µm

Water activity: Water activity is defined as the free moisture content in product. It is an essential product characteristic which influences the microbial ecology of the product [39]. It is very much important for the shelf life of the products. The water activity observed for the fresh sand slices was 0.99 ± 0.001. More the value of water activity less stable is the product *i.e.* has very less shelf life.

Total phenolic content: The total phenolic content of the sand pear fruit found was 10.33 ± 0.17 mg/100 g gallic acid. This is higher than those of tropical fruits such as bananas, oranges or papaya [40]. Polyphenols are usually involved in the resistance against the ultraviolet radiations and also provide protection against the development of cancer, diabetes, cardio vascular diseases, neurodegenerative diseases and osteoporosis [41]. They also inhibit the oxidation of LDL and prevent the atherosclerosis [42].

Conclusion

The current study is the primary evaluation report on the proximate, physico-chemical, nutritional, textural as well as morphological characterization of the sand pear. It was investigated that sand pear showed optimum physico-chemical properties like titratable acidity, pH and high nutritional compounds such as reducing sugars, ascorbic acid, total sugars and various minerals. Also, sand pear possessed the high dietary fiber content and high amount of total phenolic content. In addition various textural parameters were studied and can be applied to recognize the small textural changes in the sand pear flesh. Furthermore, the microstructure analysis of sand pear tissue also helps in revealing the various changes that could give an account to changes in rheology and texture of the sand pear. These results referred that sand pear cultivar could be best for consumption as fresh or after favourable processing because of excellent product quality and good concentrations of functional and nutritional components.

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